Zülicke and Shimshoni Reply: In two recent articles [1, 2], we developed a transport theory for an extended tunnel junction between two interacting fractional-quantum-Hall edge channels, obtaining analytical results for the conductance. Ponomarenko and Averin (PA) have expressed disagreement with our theoretical approach and question the validity of our results [3]. Here we show why PA's critique is unwarranted.

The system, called a *line junction*, is formed by two counterpropagating single-branch quantum-Hall edges with different fractional filling factors. It consists of three regions, as shown in Fig. 1 of Ref. [1]. A finite uniform tunneling amplitude exists only within the central segment of length L, and a (screened Coulomb) interaction *between* the two counterpropagating edge channels is present *only in that region of space* as well. Outside of the central region, tunneling and inter-edge interactions are switched off. However, interactions between electrons *within* each edge channel are considered to be finite everywhere. Our assumptions about the spatial variation of tunneling and interactions are designed to provide a realistic model of experimentally relevant situations [4].

The inherent non-uniformity of the system under consideration makes it necessary to implement proper matching conditions at the interface between the central region and adjacent (lead) regions. This is the crux of our disagreement with PA. Their results are based on the assumption that the bosonic fields describing edge excitations in the two counterpropagating branches should be continuous. This approach has been successfully used to study tunneling transport through point contacts between edge channels with *uniform* interaction potential. However, PA's assumption will not hold for our line junction because it ignores charging of the central region due to the spatially inhomogeneous (piecewise-constant) interedge interaction. Similar charging effects occur in a finite interacting quantum wire that is attached to non-interacting one-dimensional leads [5, 6]. To properly account for these, a different set of boundary conditions needs to be imposed.

Instead of the unphysical requirement of continuous bosonic fields (and, hence, edge-charge densities), we demand continuity of a quantity we call the local chemical potential μ_i for each edge mode. It is defined as the functional derivative of the total system Hamiltonian w.r.t. the chiral edge density, $\mu_j(x) = \delta \mathcal{H}/\delta \varrho_j(x)$, and is therefore the operator field that is canonically conjugate to ϱ_j . A detailed discussion of this quantity's physical meaning can be found, e.g., in Ref. 7. (See also related articles [8].) Its expectation value corresponds to an electrochemical potential that would be established after electronic equilibration. The utility of the operators μ_i arises from the fact that they are well-defined everywhere in the system, irrespective of whether and where equilibration actually occurs. In particular, they are constant in the lead regions where the chiral edge densities cannot change. Requiring continuity of the μ_i operators at an interface where electron interactions are discontinuous amounts to implementing the proper self-consistent solution of the equivalent of Poisson's equation for a short-ranged interaction potential [5, 6].

Contrary to PA's claim, we *do not* impose equilibration in outgoing edge-channel leads at their interface with the central

line-junction region. We demonstrate this fact by re-deriving our central result, relating the junction current I_J to the voltage drop [Eq. (36) in Ref. 2], with explicit reference only to chemical potentials μ_1 and μ_3 of *incoming* edge-channel leads.

Without loss of generality, we choose the chirality of edge channels in the line junction as shown in Fig. 1b of Ref. 1. The local chemical potential of right-movers (left-movers) at x = -L/2 (x = L/2) is fixed by the incoming edge-channel leads to be equal to μ_1 (μ_3). Straightforward algebra yields

$$\mu_1 = \frac{2\pi\hbar}{\nu_{\rm R}} \left\{ \sqrt{\tilde{\nu}} v_{\rm n} \varrho_{\rm n} \left(-\frac{L}{2} \right) + \frac{I_{\rm J}}{2} \right\} + \frac{2\pi\hbar v_{\rm c} \varrho_{\rm c} \left(-\frac{L}{2} \right)}{|\nu_{\rm R} - \nu_{\rm L}|}$$
(1a)

$$\mu_{3} = \frac{2\pi\hbar}{\nu_{L}} \left\{ \sqrt{\tilde{\nu}} v_{n} \varrho_{n} \left(\frac{L}{2} \right) - \frac{I_{J}}{2} \right\} + \frac{2\pi\hbar v_{c} \varrho_{c} \left(\frac{L}{2} \right)}{|\nu_{R} - \nu_{L}|}. \quad (1b)$$

The charge mode has a trivial dynamics and satisfies $\varrho_{\rm c}(L/2) \equiv \varrho_{\rm c}(-L/2)$. Hence we find the general relation

$$\frac{\mu_1 - \mu_3}{2\pi\hbar} = \sqrt{\tilde{\nu}} \, v_{\rm n} \left[\frac{\varrho_{\rm n} \left(-\frac{L}{2} \right)}{\nu_{\rm R}} - \frac{\varrho_{\rm n} \left(\frac{L}{2} \right)}{\nu_{\rm L}} \right] + \frac{\nu_{\rm R} + \nu_{\rm L}}{2\nu_{\rm R} \nu_{\rm L}} \, I_{\rm J} \,. \quad (2)$$

Some more algebra based on the continuity equation for the neutral mode (see Sec. III of Ref. 2) yields the condition $\varrho_n(L/2)=\varrho_n(-L/2)\equiv\bar{\varrho}_n$ for the stationary limit. With that, Eq. (2) above specializes to the quoted voltage-drop equation for the line junction, ostensibly derived in Ref. 2 by matching local chemical potentials at interfaces. Here we find the same result without considering chemical potentials in outgoing leads, thus confirming the accuracy of our approach.

Unlike in point contacts, an externally imposed voltage at a line junction sustains both the current I_J and a charge imbalance $\bar{\varrho}_n$, which are related by the central region's dynamics. PA's result for the conductance can arise only in the limit of vanishing $\bar{\varrho}_n$, which we consider to be unphysical because it implies the absence of an internal driving force for the current.

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